Therefore it was decided that the rating of these urban areas should be left to a more in-depth study or model.

d) Rating System of Recharge Layer

The "recharge" map was generated by merging the three sources of information on land cover. Each resulting recharge class was given the following point rating to be used in determining relative vulnerability. The sources of highest recharge were given the highest point rating. These point ratings may be adjusted in the future after comparison to ground water monitoring data. Figure 4 shows the distribution of these classes throughout the Snake River Plain.

Recharge Classes	Rating (points)
Gravity-fed irrigated land	50
Riparian areas	50
Sprinkler-fed irrigated land	40
Forests	30
Dryland agriculture	20
Rangeland	20
Bare rock (lava flows)	10
Urban areas	No rating
Surface water	No rating

3) **Soils**

a) Introduction

The soils layer is an important factor in determining ground water susceptibility because it acts as the first barrier to potential ground water contamination. For the purposes of this project, contaminants were assumed to have the same mobility and characteristics as water. Additional data layers can be developed in the future to evaluate the migration of specific classes of contaminants, whether it be solvents, various types of pesticides, or petroleum hydrocarbons. This study defined the soil layer as the uppermost 60 inches (5 ft) of land surface.

The Idaho Ground Water Vulnerability Project incorporated the State Soils Geographic Database (STATSGO) and SOILS-5 database developed by the U.S.D.A. Soil Conservation Service (SCS). STATSGO is a general soils database which consists of two parts; a spatial (map) component based on USGS topographic maps at a scale of 1:250,000, and an attribute data base consisting of tabular soils data. The SOILS-5 database was the source for the tabular soils data for STATSGO. SOILS-5 provides information on a broad range of chemical and physical soil characteristics, and develops interpretations for various uses of the soils based on these characteristics. Particular attributes that were pertinent to the vulnerability project were extracted from the SOILS-5 database and used in conjunction with the soils map (Figure 5).

A single STATSGO soil mapping unit may include several soil series and their phases. Soil "series" are defined as "a collection of soil individuals essentially uniform in differentiating characteristics and in arrangement of horizons" (Brady, 1974). Series are typically derived from the same kind of parent material by the same genetic combination of processes. Series are established on the basis of profile characteristics, which include the number, order, thickness, texture, structure, color, organic content, and reaction (acid, neutral, or alkaline) of the various horizons. A soil "phase" is a subdivision of a soil series on the basis of some important non-pedogenic factor such as surface texture, erosion, slope, stoniness, or soluble salt content.

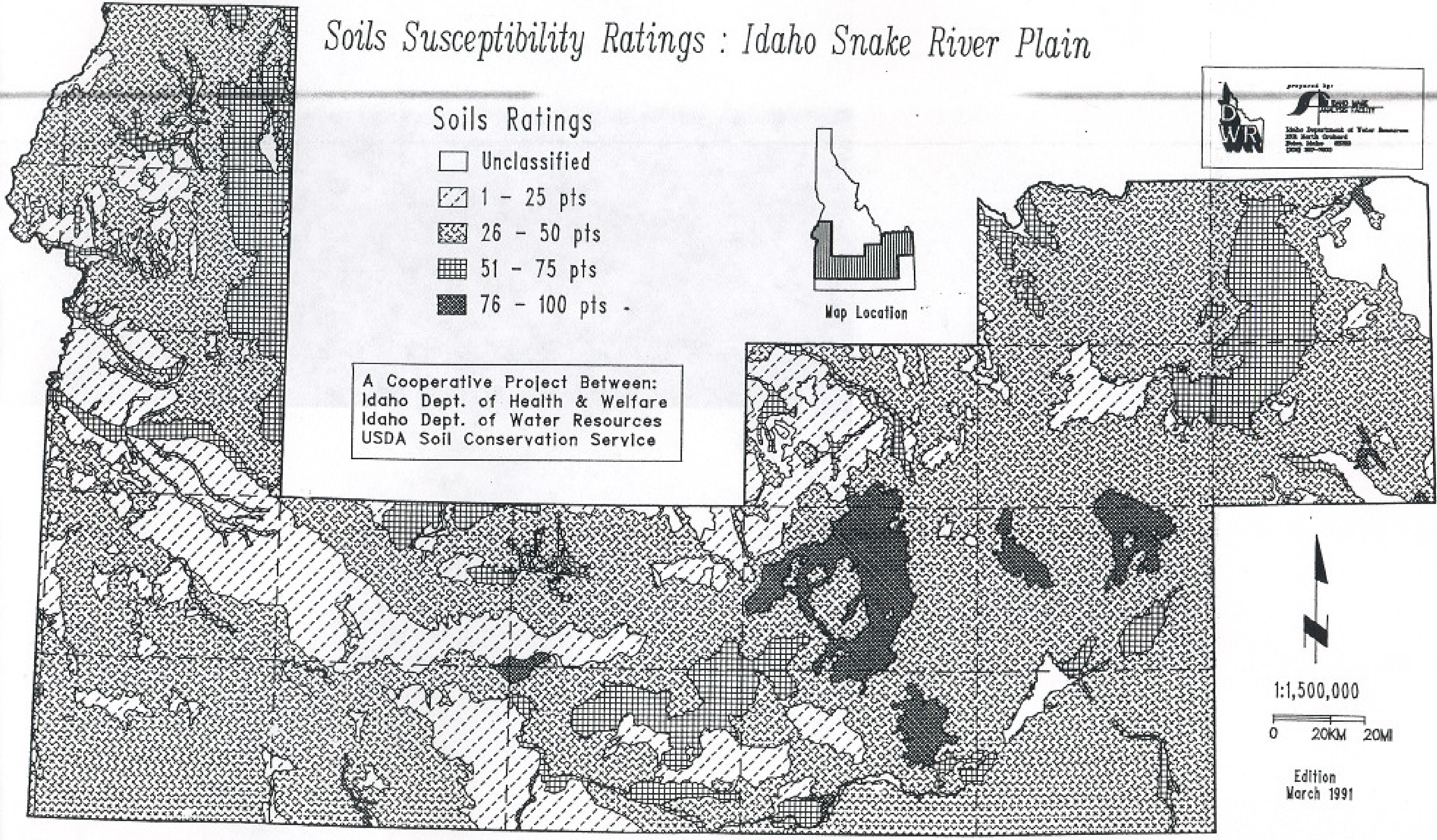
b) Rating System of Soils Layer

Several soil-landscape characteristics were chosen to be included in the soils layer from the information available in the SOILS-5 database. These characteristics are: 1) permeability of the most restrictive layer; 2) depth-to-water table within the soil horizon; 3) depth to bedrock; and 4) flooding frequency. The point rating systems for these characteristics may be changed in the future as more information is gained, and after comparison to ground water monitoring data.

1) Permeability

Permeability class of the most restrictive layer was chosen because it was thought to reflect a greater range of soil characteristics that influence water movement than did soil texture alone. Permeability class uses many characteristics, which include; texture, structure, pore-size distribution, density, clay mineralogy, consistence, organic matter content, and rooting distribution.

Permeability class was rated on a point scale to represent the relative influence of a particular class to ground water susceptibility. The following is a table of the point rating scheme for the permeability class of the most restrictive layer:



Soils map, Snake River Plain, Idaho
STATSGO data is preliminary and is subject to change

PERMEABILITY (in./hr.)		RATING (points)
no soil		20
very rapid	(>20.0)	20
rapid	(6.0-20.0)	16
mod. rapid	(2.0-6.0)	12
moderate	(0.6-2.0)	8
mod. slow	(0.2-0.6)	6
slow	(0.06-0.2)	4
very slow	(<0.06)	2
limiting layers (e.g. duripan)		2

As each soil series was evaluated, the particular horizon sequence, horizon thickness, permeability of horizons other than the most restrictive layer, and other unique features were noted. These features were then evaluated in terms of how they affect soil water movement in determining the final permeability class chosen for that soil.

If a soil had strongly contrasting permeability classes within 60 inches of the surface (moderate rating of 8 pts overlying very rapid with a rating of 20) the rating was typically increased to reflect the extremely high permeability of the subsoil. In this example, the rating would change from 8 to 20.

The rating was also increased if the thickness of the layer of lowest permeability, such as an argillic horizon was less than 6 to 12 inches. If the high seasonal water table was shown to be near or within a surficial horizon of higher permeability the rating for that higher permeability class was used. Soils with very slow permeability and cracking, shrink-swell clays were treated as if they were in the wetted, closed condition.

The rating of soils with thin (< six inches), moderately or weakly cemented duripans over sand or gravel was increased to reflect the lowest permeability in the portion of the profile above the duripan. If there was a duripan less than six inches thick overlying bedrock, the duripan was ignored and the permeability of the least restrictive layer above the duripan was used.

2) Depth to water-table

Depth to water-table (presence or absence within the upper five feet of soil) was chosen to supplement in more detail the layer on depth-to-water that was developed for this project by the USGS (Maupin, in press-a; Maupin, in press-b). This characteristic was included in the rating scheme because ground water within the uppermost 60 inches of soil poses a situation particularly susceptible to ground water contamination. For instance, during the irrigation season water-tables are often the highest and this coincides with those times when agricultural chemicals are more likely to be in use. The high water-tables identified by the SCS may in some cases represent perched, shallow aquifers of limited areal extent. For the purposes of this project all areas where high seasonal ground water was identified were assumed to be leaky and in hydraulic connectivity with deeper aquifers.

The following is a table of the point rating scheme for the depth to water-table class:

DEPTH TO WATER-TABLE	RATING (points)
water-table within 60 inches	8
water-table greater than 60 inches	0

3) Depth to Bedrock

Depth to bedrock adds information that is applicable to the evaluation of travel times to ground water, particularly when considered together with permeability and depth-to-water information. Depths greater than five feet are lumped into one class. This characteristic was chosen because large portions of Idaho (particularly southern Idaho) are underlain by relatively uniform basalts, whose transmissive properties have been studied and are reasonably well understood. Depth to this material is therefore of importance. The occurrence of different bedrock types was not considered.

DEPTH TO BEDROCK (inches)		RATING (points)
absent	(no soil)	10
very shallow	(0-10)	9
shallow	(10-20)	8
mod. deep	(20-40)	5
deep	(40-60)	2
very deep	(>60)	1

4) Flooding Frequency

Flooding Frequency was chosen to give an additional representation of recharge, which can act to move pollutants more quickly towards ground water. It was felt that when a flooding event occurred over a given soil an additional pressure head would develop. The more frequently a soil was subjected to flooding, the greater the rate of water movement, particularly in a vertical direction. Flooding frequency, as well as depth to water-table, can be considered landscape factors rather than soil factors. They give more detailed information on the relative susceptibility of ground water to pollutants moving through the soil in a particular geomorphic setting. Factors such as the severity of flooding, its timing in relation to soil moisture conditions and agricultural chemical applications, and the potential for removal of pollutants to surface water were not considered.

The following is a table of the point rating scheme for the flooding frequency class:

FLOODING FREQUENCY	RATING (points)
frequent	5
occasional	4
rare	2
none	0

c) STATSGO Soil Unit Weighting System

As mentioned before, many of the STATSGO soils units consist of several soil series and their phases. The ratings for the various series and their phases were weighted to reflect the percent of the STATSGO mapping unit that each soil series and/or phase occupied. The weighted values for each soil series and/or phase were then summed to arrive at a susceptibility rating for the entire mapping unit as follows:

1) For each mapping unit, from information on composition supplied by the SCS, the dominant soil series and phases were identified. The number of series and/or phases to include in developing a rating was determined by this procedure:

a) If one soil series and/or phase does not equal 85% or greater of the entire mapping unit, then the next most dominant soil series and/or phase was added. If their combined area is less than 85% then a third series and/or phase was added.

b) With three or more series and/or phases, their combined percentage need only be greater than or equal to 80% of the entire mapping unit.

2) The numerical ratings for each of the four factors were summed for each of the dominant soil series and/or phase found in the mapping unit and multiplied by the percentage of the entire mapping unit that each soil series and/or phase occupies. These values were then summed over all soils in the map unit. This is illustrated in the table below.

SOIL SERIES	%	PERM.	DEPBDRK	DEPWATR	FLDFREQ	RATING
Newdale	24 *	(2 +	1 +	8 +	4) =	360
Wheelerville	15 *	(20 +	8 +	0 +	0) =	420
Rexburg	57 *	(8 +	1 +	0 +	0) =	513
TOTAL	96% pts					1293

3) The summed value (1293) was then normalized for the percentage of soils in the map unit used in the calculation (96%). In this case, 1293 would be divided by 96 to come up with a weighted soils susceptibility rating of 13 points for that STATSGO soils unit.

The weighted score for each STATSGO mapping unit was then multiplied by three to determine the final soils susceptibility rating. This gives a maximum possible rating of 120 points (although scores did not exceed 100 points), giving the soils layer a maximum relative importance of 2.4 times over the other two layers. The soils layer received a greater weighting because the soils layer incorporates more than one criteria which determine susceptibility assessment (permeability, depth to bedrock, depth to water-table, and flooding frequency), whereas the depth-to-water and recharge layers only rate one criteria (Mike Ciscell, former Remote Sensing Analyst, IDWR, personal communication, January, 1991).

VULNERABILITY MAP

1) Development of the Vulnerability Map

The Ground Water Vulnerability map (Figure 6) was generated by merging the three maps (depth-to-water, recharge, and soils) into one map using GIS techniques. The point ratings from each map were added together to create a final map with additive vulnerability point scores.

The vulnerability map was then broken into low, moderate, high, and very high vulnerability categories. The division points for these categories were derived by graphing the relationship of total acres versus total vulnerability score (Figure 7). The top ten percent with the highest